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Lower respiratory symptoms associated with environmental and reconstruction exposures after Hurricane Sandy

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Abstract

Objective—In a population with prior exposure to the World Trade Center (WTC) disaster, this study sought to determine the relationship between Hurricane Sandy-related inhalation exposures and post-Sandy lower respiratory symptoms (LRS).

Methods—Participants included 3,835 WTC Health Registry enrollees who completed Wave 3 (2011–2012) and Hurricane Sandy (2013) surveys. The Sandy-related inhalational exposures examined were: 1) reconstruction exposure; 2) mold or damp environment exposure; and 3) other respiratory irritants exposure. LRS were defined as wheezing, persistent cough, or shortness of breath reported on ≥1 of the 30 days preceding survey completion. Associations between LRS and Sandy exposures, controlling for socio-demographic factors, post-traumatic stress disorder, and previously reported LRS and asthma were examined using multiple logistic regression.

Results—Over one-third of participants (34.4%) reported post-Sandy LRS. Each of the individual exposures was also independently associated with post-Sandy LRS, each having approximately twice the odds of having post-Sandy LRS. We found a dose-response relationship between the number of types of Sandy-related exposures reported and post-Sandy LRS.

Conclusions—This study provides evidence that post-hurricane clean-up and reconstruction exposures can increase the risk for LRS. Public health interventions should emphasize the importance of safe remediation practices and recommend use of personal protective equipment.

Keywords

Hurricane Sandy; World Trade Center; respiratory

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Authors' Contribution

Dr. Gargano designed the study, performed the statistical analyses, and wrote the first draft of the manuscript. Drs. Brackbill and Jordan and Mr. Locke contributed to the study design and analyses. All authors contributed to data interpretation and to the revision of the manuscript. All authors have approved the final manuscript.

Introduction

Hurricane Sandy (Sandy) was the largest Atlantic hurricane on record and the 2nd most costly hurricane in U.S. history after Hurricane Katrina.[1] When Sandy hit New York City on October 29, 2012, the East River overflowed its banks, flooding large areas of lower Manhattan. The Atlantic Ocean storm surge also caused considerable flood damage in Queens, Brooklyn, and Staten Island, displacing thousands of people.[2]

The extensive flooding created environmental conditions that could potentially lead to an increased risk of lower respiratory symptoms (LRS). For instance, sediment left behind after floodwaters receded could have been disturbed during recovery efforts, thus posing a risk of inhalational injury. Such dust could potentially contain irritants and toxins such as volatile pollutants, solvent emissions, or asbestos.[3–5]

Flooding also creates ideal conditions for the growth of mold, which has been reported as a risk factor for LRS.[67] In addition to mold growth, excessive indoor dampness is a source of several potentially problematic exposures such as dust mites and microbial growth. Furthermore, standing water supports cockroach and rodent infestations, and excessive moisture may initiate chemical emissions from building materials and furnishings.[8]

Beyond the flooding and potential for mold growth, power outages were extensive, requiring the use of numerous generators, which created odorous exhaust fumes.[3,9] Relief centers were set up in parking lots and consisted of heated trailers that produced combustion fumes.[3] Construction vehicles and trucks emitted diesel exhaust and, along with automobiles, created clouds of suspended sand, debris, and dust as they moved along the roads.[3] Additionally, exposure to dust containing microbial and other agents could have occurred during demolition, removal, and repair of flood-damaged and contaminated infrastructure and building materials.[10–12] Each of these exposures has been associated with respiratory symptoms.[3,12,13]

There is some evidence that Sandy-related exposures led to an increase in LRS and associated hospitalizations. For instance, a study of Long Island emergency departments found a 4% increase in visits for diseases of the respiratory system in the month following Sandy, compared to the month before.[14] However, this and other published studies of post-Sandy health effects focused on emergency department visits or hospitalizations, and did not assess the relationship between specific, individual-level exposures and subsequent LRS.[3,4,14,15] More information is needed to better understand the scope of post-Sandy respiratory issues, as well as how pre-existing respiratory symptoms and conditions contributed to the respiratory effects of Sandy-related exposures. In the current study, we sought to 1) describe exposures to respiratory hazards following Sandy, 2) examine the prevalence of post-Sandy LRS, 3) assess whether post-Sandy exposures were associated with subsequent LRS, and 4) determine whether the relationship between Sandy-related exposures and subsequent LRS differed according to the presence/absence of pre-existing respiratory problems.

Methods

Study Design and Sample Selection

We used data on a sample of WTC Health Registry (Registry) participants who were potentially affected by Hurricane Sandy. The Registry is a longitudinal cohort study designed to monitor the health of persons exposed to the 9/11/2001 WTC terrorist attacks. In 2003–2004 the Registry enrolled and surveyed 71,430 individuals exposed to the 9/11 attacks (Wave 1). Follow-up surveys were conducted in 2006–2007 (Wave 2) and 2011–2012 (Wave 3). Wave 3 data collection ended in March 2012, seven months prior to Hurricane Sandy. The 43,134 enrollees who completed Wave 3 and lived in the tri-state metropolitan area (New York, New Jersey, and Connecticut) constituted the sample pool for the Sandy sub-study. Based on the Federal Emergency Management Agency (FEMA) Modeling Task Force estimated hurricane inundation zones in the NYC tristate metropolitan area (New York, New Jersey, and Connecticut)[9], the sample pool was divided into 2 groups according to their residential location. The first group consisted of enrollees who lived in a Sandy inundation zone as defined by FEMA (N = 4,435), while a comparison group of the same size was selected randomly from the subset of enrollees with a current tri-state area address outside the inundation zone (N=4,435). Beginning March 28, 2013, the 8,870 enrollees were invited via mail or email to complete a survey by paper or web regarding Sandy-related exposures and physical and mental health. After multiple reminders, 4,558 (51.4%) completed surveys were received (2,443 from the inundation zone; 2,115 from the non-inundation zone) by November 7, 2013. Additional details on Registry recruitment and data collection and sample selection for the Hurricane Sandy sub-study are available elsewhere.[16,17] The Registry and Hurricane Sandy studies were approved by the New York City Department of Health and Mental Hygiene's Institutional Review Board.

The current study included enrollees who completed the Hurricane Sandy survey as well as Registry Waves 1, 2, and 3. Enrollees aged less than 18 years on 9/11 were excluded (N=494), resulting in a final analytic sample of 3,835.

Lower Respiratory Symptoms (LRS)

On both the Wave 3 (2010–11) and Hurricane Sandy (2013) questionnaires, LRS were defined as wheezing, persistent cough, or shortness of breath reported on at least one of the 30 days preceding survey completion, excluding times when a cold, the flu, or seasonal allergies were present.[18] LRS reported prior to Sandy were used as predictors of future symptoms, and LRS reported post-Sandy were the outcome, or dependent variable.

Hurricane Sandy Exposure Variables

We examined three types of Hurricane Sandy-related inhalational exposures: 1) reconstruction exposure (removing water, removing mud/debris or "muck", "tear out" work, or major repair at the respondent's or someone else's homes that were damaged by Sandy); 2) exposure to mold or damp environments (for those who returned home after the hurricane, having a flooded home, seeing mold, or smelling mold at home; or being exposed to sewage, dirty or contaminated flood water, or visible mold); and 3) exposure to other respiratory irritants (i.e., debris, exhaust fumes from generators, diesel fuel or heating oil leaks or

spills). Hurricane Sandy exposures were analyzed separately, in a single model, and as a count variable (i.e., no exposures, one exposure, two exposures, or all three types of exposure).

Demographic and Physical Health Variables

Sociodemographic information (gender, age, race/ethnicity, household income in 2010, and education), smoking history, body mass index, and self-reported history of clinician-diagnosed asthma were obtained from the Wave 1, 2, or 3 surveys.

Post-Traumatic Stress Disorder (PTSD)

PTSD was included because previous work among 9/11-exposed populations showed an association between LRS and PTSD.[18–20] Probable PTSD was assessed at Wave 3 with the 17-item 9/11-specific PTSD Checklist (PCL-17), which reflects DSM-IV criteria for PTSD (re-experiencing, avoiding, hyper-arousal).[21] Respondents rated symptom severity on a five-level Likert scale from not at all (1) to extremely (5). 9/11-related PTSD was defined as a PCL score of ≥ 44 on the Wave 3 survey.[17,22]

Data Analysis

Chi-square tests were used to test the statistical significance of associations between LRS and sociodemographic characteristics, symptoms, PTSD, and Hurricane Sandy exposures. Multivariable logistic regression models adjusted for variables significant at the bivariate level were used to assess associations between Hurricane Sandy exposures and LRS. To examine whether factors associated with post-Sandy LRS were different among persons with and without pre-existing LRS, we also conducted a multivariable analysis stratified on the presence or absence of LRS at Wave 3. To assess for dose-response for the number of exposures reported, a Cochran-Armitage Trend test was performed. All analyses were conducted using SAS Version 9.4.

Results

Characteristics of the Study Population

Participants were predominantly male (56.8%), 45–64 years of age at the time Sandy occurred (64.7%), non-Hispanic white (73.2%), and had at least some college education (41.9%) (Table 1). Over half had never smoked (52.7%) and 31.4% were obese. At Wave 3 (2011–12), 17.8% had probable PTSD and 45.4% reported at least one LRS. Over a quarter (26.8%) of participants reported a history of clinician-diagnosed asthma on the Wave 1, 2, or 3 surveys.

Lower Respiratory Symptoms after Hurricane Sandy

Over one-third (34.4%) reported at least one LRS on their Hurricane Sandy Survey (Table 1). Of those who reported post-Sandy LRS, 41.5% reported one symptom, 30.1% reported two, and 28.4% reported all three. Older age, male sex, lower educational attainment, current smoking, and obesity were associated with post-Sandy LRS in bivariate analysis (Table 1). Compared to participants without PTSD, a higher proportion of those with PTSD reported

LRS on their Hurricane Sandy survey (60.0% vs. 28.2%). Moreover, a higher proportion of those who reported LRS at Wave 3 also reported LRS on their Hurricane Sandy survey (57.2%) compared to those who did not report LRS at Wave 3 (15.5%). Enrollees who reported a history of clinician-diagnosed asthma also had a higher prevalence of post-Sandy LRS (54.6% vs. 26.5% among those without asthma).

Hurricane Sandy Exposures and post Hurricane Sandy Lower Respiratory Symptoms

One-third (33.1%) of the study participants reported reconstruction exposure. Similar proportions reported having mold/damp environment and other respiratory irritant exposures (36.8% and 37.9%, respectively; Table 1). More than half of participants reported having experienced at least one type of Sandy-related inhalational exposure.

When the association of Hurricane Sandy exposures and post-Sandy LRS was assessed in separate multivariable models (one for each inhalational exposure type), participants with reconstruction exposure had an adjusted odds ratio (AOR) for post-Sandy LRS of 1.8 compared to those without such exposure [95% confidence interval (CI): 1.5–2.1] (Table 2). Those who reported mold/damp environment exposure had twice the odds of having post-Sandy LRS than those without such exposure (AOR 2.0; 95% CI: 1.7–2.4). Those who reported exposure to other irritants also had more than twice the odds of having post-Sandy LRS compared to those who did not report exposure to other irritants (AOR: 2.2; 95% CI: 1.8–2.6) (Table 2). When all three exposures were put in a single model, the associations with post-Sandy LRS were attenuated but remained statistically significant for mold/damp environment exposure (AOR: 1.3, 95% CI: 1.1–1.7) and other irritant exposure (AOR 1.7, 95% CI: 1.3–2.1; data not shown).

We found a significant dose-response relationship ($p<0.0001$) between the number of exposure types reported and the odds of post-Sandy LRS (Figure 1). Compared to participants who reported no exposures, those who reported one type of exposure had twice the odds of having post-Sandy LRS (AOR: 2.1; 95% CI: 1.6–2.6) while those who reported all three types of exposures had nearly three times the odds of having post-Sandy LRS (AOR: 2.7; 95% CI: 2.1–3.4) (Figure 1).

Stratification by LRS at Wave 3

Associations between Hurricane Sandy exposures and post-Sandy LRS were similar for enrollees who reported LRS at Wave 3 and those who did not (Table 2).

Discussion

We found that exposure to mold/damp environments, reconstruction work, and other potential respiratory irritants were each independently associated with post-Sandy LRS. In addition, there was a dose-response relationship between the number of exposure types reported and the odds of post-Sandy LRS. The magnitude of the association between these exposures and post-Sandy LRS was similar for participants with and without pre-existing LRS, suggesting that the Sandy-related exposures were risk factors for both new-onset LRS and the persistence or exacerbation of pre-existing LRS.

Exposure to damp or moldy indoor space has been found to be associated with respiratory symptoms, including wheezing and cough,[8] as well as with more severe symptoms among persons with asthma.[1] However, a review of studies of the health effects of exposure to mold in the months following Hurricanes Katrina and Rita found no increase in the occurrence of adverse health outcomes, including respiratory symptoms.[10] Our current study thus adds new evidence that exposure to moldy or damp conditions in the home after hurricane-related flooding may cause or worsen LRS, underscoring the importance of prompt remediation of such conditions.

Less is known about reconstruction exposures and their associations with LRS. These exposures include inhalation of dust; removal of building materials; and other repair work of infrastructure post-hurricane, all of which could potentially introduce environmental triggers for respiratory symptoms. Our results align with those of Rando et al., who found that the prevalence rate ratios for respiratory issues such as sinusitis, fever, and cough were significantly elevated among restoration workers after Hurricane Katrina.[12] Prevalence rate ratios were also elevated for new-onset asthma, although this did not reach the level of statistical significance.[12]

We also found that exposure to irritants such as exhaust fumes from generators or diesel fuel was associated with increased odds of post-Sandy LRS. There has been one report of diesel and silica monitoring following Sandy which found that the daily average levels of elemental carbon and airborne particulates were in the ranges that have been found to cause respiratory effects in sensitive subpopulations, such as asthmatic patients, after two hours of exposure.[3] An analysis of poison control center data found a significant increase in gasoline exposures after Sandy, with pulmonary symptoms as one of the top toxic effects.[4] This suggests that disaster plans should incorporate public health messaging regarding potentially toxic exposure to diesel and gasoline.

Additional research is needed on the relationship between post-hurricane exposures and respiratory effects. Questions of exposure and dose have not, by and large, been resolved. Beyond this study, few studies to date have considered whether there are additive or synergistic interactions among different types of exposures. Longer-term studies are ongoing to further evaluate the impact of mold on the health of children and workers.[10] After Sandy, government agencies provided guidance on avoiding mold and other exposures, including wearing an N95 dust mask and other personal protective equipment, having appropriate ventilation in work areas, and proper disposal procedures.[23,24] Studies are needed to evaluate the effectiveness of various means of protection during remediation activities.

Strengths and Limitations

The availability of pre-Sandy information on this cohort, including data on LRS, asthma, PTSD, and other comorbidities, enabled us to account for prior history when assessing the relationship between Sandy-related exposures and subsequent LRS. We were also able to describe a broad range of post-hurricane exposures that resulted from circumstances and activities related to reconstruction work or returning home after a disaster, and to assess the relationship between various types of post-Sandy exposures and LRS. Nonetheless, this study also has several limitations. We did not collect data on the use of personal protective

gear, such as respirators, which may mitigate post-exposure LRS. In addition, exposure data for Sandy were self-reported and were collected at the same time when post-Sandy LRS were assessed, which could potentially bias reporting. Another possible limitation is selection bias; survey respondents may have chosen to participate because they perceived that they had greater exposure to Sandy and/or experienced more prolonged or severe symptoms.

Conclusions

Exposure to multiple sources of potential respiratory irritants after Hurricane Sandy, including mold/damp environments, irritants from reconstruction, and diesel exhaust, was associated with an increased risk of subsequent LRS. Our findings highlight the importance of safe and timely remediation of damp or moldy indoor environments, and suggest that respiratory protection is important for persons conducting reconstruction and clean-up work after a hurricane.

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References

1. Landsea, C. [Accessed 3/24, 2016] The thirty costliest mainland United States tropical cyclones 1900–2013. NOAA HRD Frequently Asked Questions. 2013. http://www.aoml.noaa.gov/hrd/tcfaq/E13.html
2. Abramson DM, Redlener I. Hurricane sandy: lessons learned, again. Disaster Med Public Health Prep. Dec; 2012 6(4):328–329. [PubMed: 23241461]
3. Freund A, Zuckerman N, Luo H, Hsu HH, Lucchini R. Diesel and Silica Monitoring at Two Sites Following Hurricane Sandy. J Occup Environ Hyg. 2014; 11(9):D131–D143. [PubMed: 25046545]
4. Kim HK, Takematsu M, Biary R, Williams N, Hoffman RS, Smith SW. Epidemic gasoline exposures following Hurricane Sandy. Prehosp Disaster Med. Dec; 2013 28(6):586–591. [PubMed: 24237625]
5. Mandigo AC, DiScenza DJ, Keimowitz AR, Fitzgerald N. Chemical contamination of soils in the New York City area following Hurricane Sandy. Environmental geochemistry and health. Oct; 2016 38(5):1115–1124. [PubMed: 26486130]
6. Johanning E, Auger P, Morey PR, Yang CS, Olmsted E. Review of health hazards and prevention measures for response and recovery workers and volunteers after natural disasters, flooding, and water damage: mold and dampness. Environ Health Prev Med. 2014; 19(2):93–99. [PubMed: 24254802]
7. ALIGN, Community Voices Heard, Faith in New York, Make the Road NY, New York Communities for Change, VOCAL-NY. Sandy's Mold Legacy: The Unmet Need Six Months After the Storm. 2013
8. Damp indoor spaces and health. National Academies Press; 2004. Institute of Medicine Committee on Damp Indoor Spaces Health.
9. FEMA. [Accessed 3/24, 2016] New York Harbor at the Battery Hydrograph. NOAA Advanced Hydrologic Prediction Service. http://water.weather.gov/ahps2/hydrograph.php?wfo=okx&gage=batn6

10. Barbeau DN, Grimsley LF, White LE, El-Dahr JM, Lichtveld M. Mold exposure and health effects following hurricanes Katrina and Rita. Annu Rev Public Health. 2010; 31:165–178. [PubMed: 20070193]
11. Quast T, Mortensen K. Emergency department utilization in the Texas Medicaid emergency waiver following Hurricane Katrina. Medicare Medicaid Res Rev. 2012; 2(1):E1–E6.
12. Rando RJ, Lefante JJ, Freyder LM, Jones RN. Respiratory health effects associated with restoration work in post-Hurricane Katrina New Orleans. Journal Environ Public Health. 2012; 2012
13. Mount Sinai Irving J. [Accessed February 3, 2017] Selikoff Center for Occupational & Environmental Medicine. Diesel Exhaust Exposure: What to Do. 2012. http://www.usa829.org/Portals/0/Documents/Health-and-Safety/Safety-Library/Diesel-Exhaust-Exposure_What-To-Do.pdf
14. Kim H, Schwartz RM, Hirsch J, Silverman R, Liu B, Taioli E. Effect of Hurricane Sandy on Long Island emergency departments visits. Disaster Med Public Health Prep. 2016; 10(3):344–350. [PubMed: 26833178]
15. Gotanda H, Fogel J, Husk G, et al. Hurricane Sandy: impact on emergency department and hospital utilization by older adults in Lower Manhattan, New York (USA). Prehosp Disaster Med. 2015; 30(5):496–502. [PubMed: 26369433]
16. Brackbill RM, Caramanica K, Maliniak M, et al. Nonfatal injuries 1 week after Hurricane Sandy-New York City metropolitan area, October 2012. MMWR. Morbidity and mortality weekly report. 2014; 63(42):950–954. [PubMed: 25340912]
17. Caramanica K, Brackbill RM, Stellman SD, Farfel MR. Posttraumatic Stress Disorder after Hurricane Sandy among Persons Exposed to the 9/11 Disaster. International journal of emergency mental health. 2015; 17(1):356–362. [PubMed: 25960693]
18. Friedman SM, Farfel MR, Maslow CB, Cone JE, Brackbill RM, Stellman SD. Comorbid persistent lower respiratory symptoms and posttraumatic stress disorder 5–6 years post-9/11 in responders enrolled in the World Trade Center Health Registry. American journal of industrial medicine. Nov; 2013 56(11):1251–1261. [PubMed: 23794365]
19. Luft BJ, Schechter C, Kotov R, et al. Exposure, probable PTSD and lower respiratory illness among World Trade Center rescue, recovery and clean-up workers. Psychological medicine. May; 2012 42(5):1069–1079. [PubMed: 22459506]
20. Nair HP, Ekenga CC, Cone JE, Brackbill RM, Farfel MR, Stellman SD. Co-occurring lower respiratory symptoms and posttraumatic stress disorder 5 to 6 years after the World Trade Center terrorist attack. American journal of public health. Oct; 2012 102(10):1964–1973. [PubMed: 22897552]
21. Ruggiero KJ, Del Ben K, Scotti JR, Rabalais AE. Psychometric properties of the PTSD Checklist-Civilian Version. Journal of traumatic stress. Oct; 2003 16(5):495–502. [PubMed: 14584634]
22. Brackbill RM, Hadler JL, DiGrande L, et al. Asthma and posttraumatic stress symptoms 5 to 6 years following exposure to the World Trade Center terrorist attack. Jama. Aug 5; 2009 302(5): 502–516. [PubMed: 19654385]
23. New York State. [Accessed November 10, 2016] Respiratory Concerns and Mold Cleanup After Hurricane Sandy. 2013. https://www.health.ny.gov/environmental/emergency/weather/hurricane/docs/respiratory_health_flyer.pdf
24. Occupational Safety and Health Administration. [Accessed November 10, 2016] OSAH FactSheet: Mold Hazards during Hurricane Sandy Cleanup. 2012. https://www.osha.gov/Publications/OSHA-FS-3619.pdf

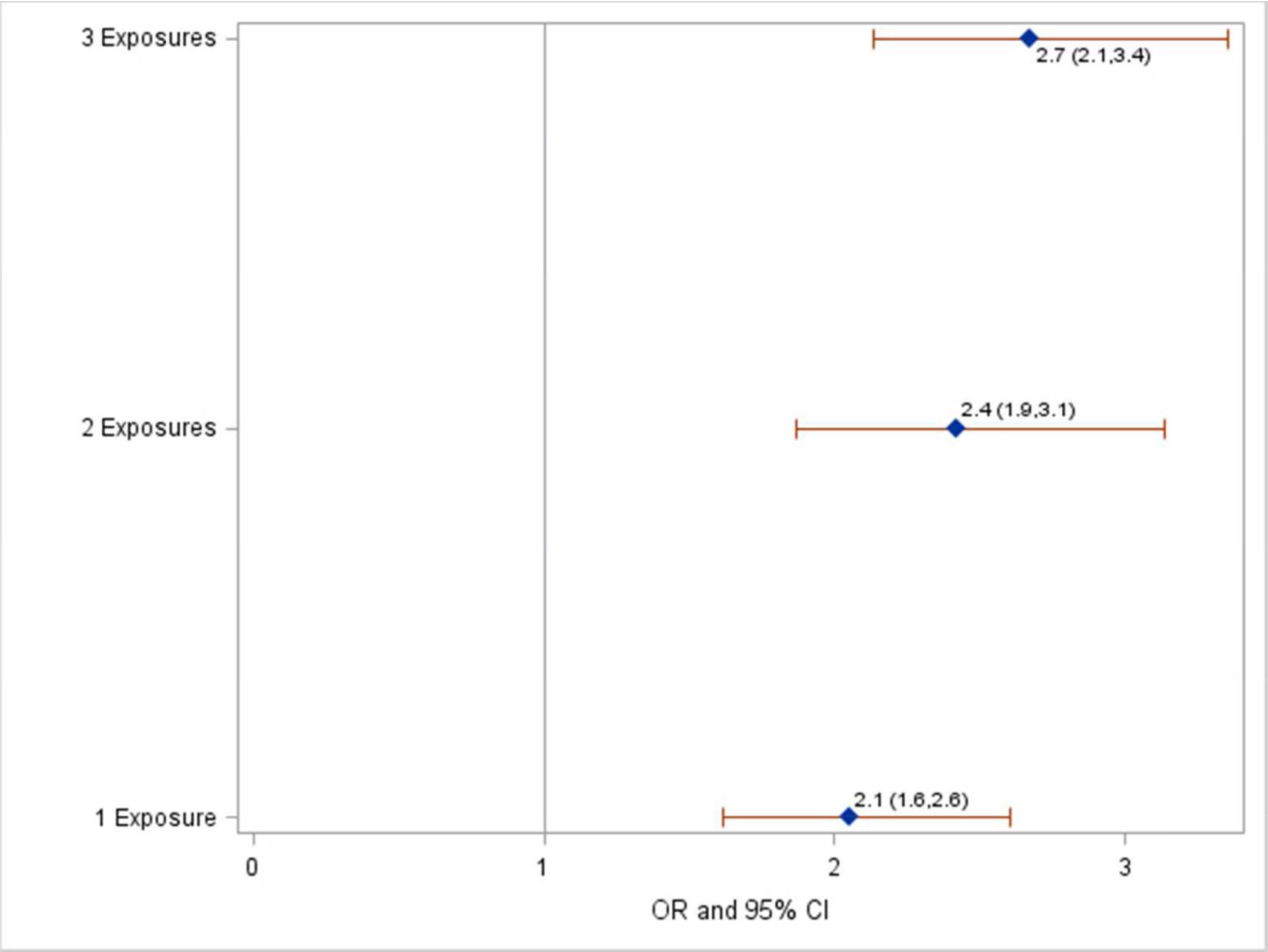

Figure 1.

Adjusted odds ratios* (AOR) for association of lower respiratory symptoms (LRS) and number of types of Hurricane Sandy-related exposures

Table 1

Characteristics of survey participants and prevalence of lower respiratory symptoms (LRS)[a] after Hurricane Sandy (2013)

			Any lower respiratory symptom*		
	Total	%	Yes	%	P-value
Total	3835	100	1319	34.4	
Gender					
Male	2178	56.8	778	35.7	0.0473
Female	1657	43.2	541	32.7	
Age (at Hurricane Sandy)					
29–44	612	16.0	145	23.7	<.0001
45–64	2481	64.7	892	36.0	
≥65	742	19.4	282	38.0	
Race/ethnicity					
White, non-Hispanic	2806	73.2	893	31.8	<.0001
Black, non-Hispanic	362	9.4	141	39.0	
Hispanic	390	10.2	164	42.05	
Asian	189	4.9	82	43.4	
Multiracial/other	88	2.3	39	44.3	
Income (2010)					
≤$50,000	874	23.8	393	45.0	<.0001
$50,001–$75,000	594	16.2	216	36.4	
$75,001–$150,000	1402	38.2	456	32.5	
>$150,000	801	21.8	196	24.5	
Highest education					
Up to some high school	121	3.2	65	53.7	<.0001
Up to some college	1603	41.9	653	40.7	
College graduate	1255	32.8	381	30.4	
Postgraduate school	849	22.2	217	25.6	
Body mass index (2011–12)					
Normal/underweight	1146	30.5	304	26.5	<.0001

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				Any lower respiratory symptom*		
		Total	%	Yes	%	P-value
	Overweight	1431	38.1	485	33.9	
	Obese	1177	31.4	499	42.4	
Posttraumatic stress disorder (2011–12)						
	Yes	653	17.8	392	60.0	<.0001
	No	3017	82.2	850	28.2	
Smoking history (2011–12)						
	Never smoker	1985	52.7	637	32.1	0.0003
	Former smoker	1390	36.9	489	35.2	
	Current smoker	393	10.4	167	42.5	
LRS (2011–12)						
	Yes	1728	45.4	989	57.2	<.0001
	No	2075	54.6	322	15.5	
Clinician-diagnosed asthma						
	Yes	1004	26.8	548	54.6	<.0001
	No	2749	73.2	728	26.5	
Reconstruction exposure[b]						
	Yes	1269	33.1	558	44.0	<.0001
	No	2566	66.9	761	29.7	
Mold/damp environment[c]						
	Yes	1410	36.8	647	45.9	<.0001
	No	2425	63.2	672	27.7	
Other irritants[d]						
	Yes	1452	37.9	645	44.4	<.0001
	No	2383	62.1	674	28.3	
Number of exposure types						
	0	1839	48.0	450	24.5	<.0001
	1	674	17.6	268	39.8	
	2	509	13.3	221	43.4	
	3	813	21.2	380	46.7	

Totals might not equal 3835 due to missing data;

[a]LRS defined as wheezing, persistent cough, or shortness of breath reported on at least one of the 30 days preceding survey completion, excluding times when a cold, the flu, or seasonal allergies were present.

[b]Reconstruction exposure: removing water, removing mud/debris or “muck”, “tear out” work, or major repair at their or someone else’s homes that were damaged by Sandy

[c]Mold or damp environments: for those who returned home after the hurricane, having a flooded home, seeing mold, or smelling mold at home; or being exposed to sewage, dirty or contaminated flood water, or visible mold

[d]Other irritants: debris, exhaust fumes from generators, diesel fuel or healing oil leaks or spills

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Table 2

Adjusted odds ratios (AOR) for associations between lower respiratory symptoms (LRS) and Hurricane Sandy exposures overall and stratified on presence/absence of LRS in 2011–2012

	All participants		Participants without LRS in 2011–12		Participants with LRS in 2011–12	
Sandy exposures	**AOR***	**95 % CI**	**AOR***	**95 % CI**	**AOR***	**95 % CI**
Reconstruction Exposure						
Yes	1.8	1.5, 2.1	1.9	1.4, 2.5	1.7	1.4, 2.2
No	reference		reference		reference	
Mold/Damp Environment						
Yes	2.0	1.7, 2.4	1.9	1.4, 2.5	2.0	1.6, 2.6
No	reference		reference		reference	
Other Irritants						
Yes	2.2	1.8, 2.6	2.4	1.8, 3.2	2.0	1.6, 2.5
No	reference		reference		reference	

*Adjusted for gender, age, race/ethnicity, income (2010), posttraumatic stress disorder (2011–12), clinician-diagnosed asthma, smoking history, obesity, education, and LRS in 2011–12 in non-stratified model